UNIVERSITI PUTRA MALAYSIA

COMPARATIVE STUDIES IN RUMEN ACTIVITIES AND UREA KINETICS BETWEEN CATTLE AND BUFFALOES

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by

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Supervisors : Professor Mohd. Mahyuddin Bin Mohd. Dahan, Ph. D.

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Faculty : Veterinary Medicine and Animal Science.

Studies in rumen activities and urea kinetics were conducted to compare the digestion between cattle and buffaloes fed fibrous diets.

On straw-based diets, buffaloes demonstrated higher rate of rumen fermentation. The rumen pH of buffaloes (6.46 $\pm$ 0.02) was lower than cattle (6.78 $\pm$ 0.02), while the VFA concentration was higher than that of cattle (98.0 $\pm$ 2.2 versus 85.5 $\pm$ 1.6 mmol/l). The rumen ammonia was also found to be higher in buffaloes (4.00 $\pm$ 0.08 mg N/100 ml) than in cattle (3.55 $\pm$ 0.08 mg N/100 ml). The rate of degradation of straw was also faster in buffaloes (0.018 $\pm$ 0.003 h^{-1}) than in cattle (0.010 $\pm$ 0.004 h^{-1}). A similar trend was observed when the animals were fed guinea grass.

Voluntary feed intake and water consumption were similar for both species fed grass, but when fed fed straw, cattle showed higher feed intake and lower water consumption than buffaloes. There was no difference between cattle and buffaloes in the rate of passage of small feed particles from the rumen and rumen fluid volume based on liveweight was also not significantly different between the two animal species. However, the fluid outflow rate from the rumen was slower in the buffaloes (1.06 $\pm$ 0.19 1/h) than in the cattle (1.55 $\pm$ 0.01 1/h).

The rumen microbial population involved in digestion of feed materials in cattle and buffaloes was studied using Scanning Electron Microscopy. The morphology of the microorganisms, their mode of attachment and colonization on feed particles were found to be similar in both cattle and buffaloes. The predominant bacterial population colonizing grass and straw fragments consisted of rods and diplococcoids but in the case of palm press fibres (PPF) they were mainly rods. Fungi producing spherical sporangia and extensive rhizoidal system were more abundant on grass and straw fragments. They also produced multi-lobed vesicles or 'appresoria' for penetrating intact plant cell walls. Multiporous spherical sporangia were also observed. Fungi producing filiform or fusiform sporangia were more abundant on PPF fragments. Very few attached protozoa were seen.

The urease activity of bacteria in the rumen liquor as well as those on the epithelial surface was determined in cattle and buffaloes. The activity was not affected by the species of animals but was influenced by diet. It was also observed that ammonia concentration had no influence on urease activity. The activity was not evenly distributed in the gastrointestinal tract. In cattle and buffaloes fed grass, higher activity was recorded on tissues along the equatorial region of the rumen. The distribution of urease activity did not follow the population distribution pattern of the wall bacteria in both cattle and buffaloes. The enzyme produced by bacteria present in the rumen liquor as well as on the epithelial wall in both animal species was far in excess of the amount of endogenous urea transferred into the rumen.

The amount of urea transferred into the rumen was determined for both cattle and buffaloes when fed rice straw with and without molasses supplementation. Increasing soluble carbohydrate did not enhance urea transferred into the rumen. Buffaloes demonstrated higher urea transfer to the rumen (6.9 $\pm$ 2.2 g N/d) compared to cattle (2.9 $\pm$ 0.7 g N/d). The buffaloes also had lower urea synthesis rate from endogenous resources than the cattle.

Some of the results from the present study indicates differences in digestion between cattle and buffaloes fed fibrous diets.

Abstrak tesis dikemukakan kepada Senat Universiti Pertanian Malaysia bagi memenuhi syarat ijazah Doktor Falsafah

KAJIAN PERBANDINGAN MENGENAI AKTIVITI RUMEN SERTA KINETIK UREA DIANTARA LEMBU DAN KERBAU

oleh

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Kajian mengenai aktiviti rumen dan kinetik urea telah dilakukan untuk membandingkan proses penghadaman oleh lembu dan kerbau yang diberi makanan berserabut.

Bila diberi makanan berdasarkan jerami padi, kerbau menunjukkan kadar fermentasi rumen yang tinggi. pH rumen kerbau (6.46 $\pm$ 0.02) adalah lebih rendah daripada lembu (6.78 $\pm$ 0.02), dan kepekatan asid lemak meruap (VFA) nya pula adalah lebih tinggi daripada lembu (98.0 $\pm$ 2.2 berbanding dengan 85.5 $\pm$ 1.6 mmol/l). Kepekatan ammonia rumen juga didapati lebih tinggi untuk kerbau (4.00 $\pm$ 0.08 mg N/100 ml) daripada untuk lembu (3.55 $\pm$ 0.08 mg N/100 ml). Kadar degradasi jerami untuk kerbau (0.018 $\pm$ 0.003/jam) adalah lebih pantas daripada untuk lembu (0.010 $\pm$ 0.003/jam). Trend yang sama dilihat bila haiwan-haiwan ini di beri makan rumput guinea.

Pengambilan makanan dan air adalah sama untuk kedua spesies bila diberi makan rumput, tetapi bila diberi jerami, pengambilan makanan adalah lebih tinggi dan pengambilan air lebih rendah untuk lembu daripada untuk kerbau. Tidak ada perbezaan diantara lembu dan kerbau dalam kadar pengaliran butir-butir kecil digesta daripada rumen dan isipadu bendalir rumen berdasarkan berat hidup juga tidak berbeza diantara kedua spesies haiwan. Kadar pengaliran keluar bendalir rumen adalah lebih perlahan untuk kerbau (1.06 $\pm$ 0.19 1/jam) daripada untuk lembu (1.55 $\pm$ 0.01 1/jam).

Pertumbuhan mikrob rumen yang terlibat dalam penghadaman bahan makanan lembu dan kerbau telah dikaji dengan kaedah 'Scanning Electron Microscope'. Perbezaan yang ketara tidak dilihat dalam jenis morfologi mikroorganisma, mod lekatan mikrob dan cara pertumbuhan koloni di butir-butir digesta diantara lembu dan kerbau. Bakteria yang predominan menumbuhi rumput dan jerami padi terdiri daripada jenis rod dan diplokokoid, tetapi untuk serabut hampas buah kelapa sawit (PPF), kebanyakan nya ialah jenis rod. Kulat dengan sporangia berbentuk sfera dan sistem rizoid yang meluas dilihat di fragmen rumput dan jerami. Kulat juga membentuk struktur 'appresoria' untuk menembusi dinding sel tumbuhan. Sporangia berbentuk sfera yang berliang (lebih daripada satu) juga di lihat. Kulat yang mengeluarkan sporangia berbentuk filifom atau fusifom lebih banyak pada fragmen PPF. Hanya sedikit sahaja protozoa yang terlekat pada digesta rumen.

Aktiviti enzim urease bakteria dalam bendalir rumen dan bakteria pada permukaan tisu epitelia usus lembu dan kerbau telah dianggarkan. Aktiviti urease tidak berbeza diantara spesies haiwan tetapi dipengaruhi oleh diet yang berlainan. Kepekatan amonia rumen juga tidak menjejaskan aktiviti enjim. Penaburan aktiviti enzim tidak serata dalam usus penghadaman. Untuk lembu dan kerbau yang diberi makan rumput, aktiviti yang tinggi telah dilihat pada tisu yang diambil dibahagian tengah rumen. Penaburan aktiviti juga tidak selaras dengan corak penaburan pertumbuhan bakteria pada tisu dinding rumen lembu dan kerbau. Amaun enzim yang dikeluarkan oleh bakteria dalam bendalir rumen dan tisu dinding rumen untuk lembu dan kerbau adalah berlebihan daripada amaun urea endogen yang dipindahkan kedalam rumen.

Jumlah urea yang dikitar semula kedalam rumen telah di anggarkan untuk lembu dan kerbau yang diberi makan jerami padi $\pm$ molasses. Penambahan karbohidrat larut tidak meningkatkan jumlah urea yang dipindahkan kedalam rumen. Kerbau menunjukkan pemindahan urea yang tinggi (6.9 $\pm$ 2.2 g N/hari) daripada lembu (2.9 $\pm$ 0.7 g N/hari). Kadar sintesis urea daripada sumber endogen juga adalah rendah untuk kerbau daripada untuk lembu.

Beberapa keputusan yang diperolehi daripada pengajian ini menunjukkan adanya perbezaan dalam proses penghadaman diantara lembu dan kerbau yang diberi makanan berserabut.

INTRODUCTION

Cattle (*Bos indicus*) and buffalo (*Bubalus bubalis*) production in Malaysia is carried out mainly by the smallholders particularly in the rice growing areas. The limited attention given to these animals so far has resulted in a slow development of the large ruminant livestock industry. Malaysia has to import about half of the total beef requirement and almost all of the dairy products consumed.

Slow growth in ruminant industry is mainly caused by inadequate supply of feeds and fodder. However, farm by-products such as rice straw and palm press fibre are abundantly available and have the potential use as animal feedstuffs.

The indigenous swamp buffalo and the local Kedah-Kelantan cattle are well adapted to the hot and humid environment. They have been found to be low producers but well suited to the production system that depends upon low quality feeding materials for the supply of nutrients.

The buffaloes are known to degrade fibrous diets better than cattle and several reasons for the difference have been suggested. Among the reasons given are that the buffaloes

have the ability to consume more feed, have a larger rumen volume, slower fluid outflow rate, slower passage rate of digesta, higher production of rumen ammonia, more efficient recycling of endogenous urea-N and a faster transfer of fine particles from the rumen.

However these information on the digestive efficiency of the buffaloes are inadequate to explain fully their superiority over cattle in utilizing low quality diet. There is thus a need to conduct comparative evaluation on the rumen environment and activities of these two species in order to obtain further information on the factors contributing to the superiority of the buffaloes in fibre digestion. The experiments carried out to achieve this objective include studies on rumen digestion, microbial population and colonization, bacterial urease activity and urea kinetics.

CHAPTER 1

LITERATURE REVIEW

Livestock Production

Buffalo and Cattle

Buffalo and cattle raising has traditionally been integrated into crop production system by Asian subsistence farmers, where draught animals play an important role in farm operations. Malaysia has a small number of large ruminants (0.5 million) compared to other South-East Asian nations like Indonesia, Thailand and the Philippines. In Java itself, there are over 1 million buffaloes and 3.8 million cattle (Petheram et al., 1985). In Thailand there are 6.1 million buffaloes and 4.5 million cattle (Wanapat, 1985) while the Philippines has about 3 million carabaos or swamp buffaloes (Momongan, 1985). The numbers quoted are only estimates and may vary with different authors. Nevertheless, the importance of these animals, especially the buffaloes for draft power, meat and milk productions is well recognised.

There are two main types of domestic buffaloes (Bubalus bubalis) based on their phenotypic characters, geographic distribution and wallowing habits. The 'River' buffaloes (with 50 diploid chromosome numbers) prefer clean running water while